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CONTENTS

Page

Plastics in Modern Lighting, by D. Starkie, M.Sc., Ph.D. - - - 173

Fellowship - - - - - - 181

Increase in Subscriptions - - 182

Sessional Meeting in London - 186

Additions to List of Members - 186

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PLASTICS IN MODERN LIGHTING FITTINGS

By D. STARKIE, M.Sc., Ph.D.

(Summary of a paper read before the Bath and Bristol Centre, on April 3rd, 1944.)

SUMMARY

The paper reviews the various methods of light control and the materials which have been available to the illumination engineer, up to the present, for employing these methods of control. The materials which have been used mostly are glass and metal, and mention is made of the disadvantages of both materials for the design and construction of lighting fittings. As the various plastics become available the illumination engineer will be allowed more scope and flexibility in his designs.

Discussing the various plastics which are available in this country, or likely to be in the near future, the author divides them into the two types, thermoplastic and thermosetting, and discusses the special characteristics of both types which make them valuable for the construction of lighting fittings. Suggestions are made as to particular applications in which plastics will prove of special value.

Introduction

In the years just prior to the outbreak of war there was developing a keen appreciation of the importance of good lighting in this country, and illumination engineers were being allowed more and more to apply their specialised knowledge of the most effective methods of providing adequate intensities and correct distribution. Thus, each illumination company had on its staff a number of specialists whose job it was to plan lighting systems for new buildings and improve existing lighting systems. In consequence, the general standards of lighting were being improved and were contributing, in no small measure, to the comfort and health of the people of this country. Nor were the decorative qualities of carefully planned lighting systems being neglected, and many architects were beginning to use lighting as an integral part of their schemes.

The lighting restrictions which have been imposed upon us during war-time have probably increased our appreciation of good lighting. It is noticeable that there has been an improvement in the quality and quantity of the lighting we are now using in our homes compared with those of the early days of the war. This period of war has made the country appreciate the true importance of street lighting, and we all look forward towards the time when street-lighting restrictions will be removed.

It seems certain that the country will take more interest in artificial lighting in the post-war years, and with that interest will come a demand for more and better lighting. The illumination engineer will be called upon to provide not only adequate intensities but also lighting which is attractive and will contribute to the comfort of the user. It is obvious, therefore, that the illumination engineer will be regarded as being of great importance in the future and much will be expected of him. It is equally obvious that there must be as little restriction on him as possible with regard to the methods and materials which will be available to him, and he should be able to take advantage of the latest techniques and developments in light-controlling materials which will be in existence. Let us consider the materials which have been available up to the commencement of the war and on which the illumination engineer has had to base his designs for lighting fittings, and then turn our attention to the new materials which will be offered to him in the future. We shall be concerned mostly with light-controlling materials and neglect those used purely for structural purposes, but we shall see that some of the new materials combine efficient light control with a mechanical strength which enables them to be used as integral parts

of the actual structure of the lighting fitting.

Older Materials Used for Lighting Fittings

Before listing the materials which have been used in the construction of lighting fittings, we should consider the various methods by which light can be controlled and distributed. These can be divided into four main methods: absorption, reflection, refraction, and diffusion.

Absorption is seldom used, since it represents a reduction in efficiency. The control exercised by absorption, namely the screening of the light in some particular direction can, in any case, usually be accomplished by other means, by which the energy which would be lost can be redirected in some direction where it can be usefully employed.

Reflection may be a highly efficient method of light control. It can be subdivided into three types: specular reflection such as is given by a mirror, diffuse reflection in which the reflected light is re-directed back in a variety of directions, and mixed reflection, in which both specular and diffuse reflections are combined. Considerable use is made of reflection as a means of distributing the light from a lighting fitting. Thus, when it is desired to project a beam of maximum intensity in some particular direction while screening it in others, as in floodlighting and shop-window lighting, specular reflection is used. An example of the use of diffuse reflection is that of indirect lighting where a relatively narrow beam of light is projected on to the ceiling of a room and the rays are diffused back from the ceiling to illuminate the whole area of the room. As examples of materials exhibiting both specular and diffuse reflection, polished opal glass and white vitreous enamelled iron can be quoted. The diffuse reflection is provided by the body of the material and the specular reflection by the polished surface.

Control of light by refraction depends upon the fact that, when a ray of light passes from one transparent medium into another of different refractive index, its direction is changed. By inclining the two boundary faces of the denser medium relative to each other, the ray of light can be directed into a selected direction. An example of the use of refraction in controlling light distribution is a street lighting refractor bowl. There are factors which make it inadvisable to attempt to turn the rays through too great an angle by refraction, but nevertheless the method is of great importance.

The last method of control is by diffusion. This method is usually employed when it is desired to make the surface brightness of a lighting unit less than that of the source, but it is also possible to control the distribution of the light by this means so as to give higher intensities in certain preferred directions. Thus, with a good diffusing material completely surrounding the light source, the intensity in a particular direction depends on the area of the globe as seen from that direction.

Let us now consider the materials which have been available to the designer of lighting fittings and which have allowed him to utilise these various methods of light control. In using absorption he has had to rely on metal, or some other opaque material, or absorbing glass. Specular reflection has been obtained by using polished or plated metal and silvered or prismatic glass, while painted materials, mainly metals, have been available to him for diffuse reflection. Vitreous enamelled iron and dense opal glass have provided him with mixed reflection. Control by refraction has been obtained practically entirely by the use of glass, and, again, glass has been the main material employed for diffusion. The materials mentioned do not represent the entire range which has been available to the illumination engineer, but they are the main materials on which he has relied in designing his fittings. It will be noticed that glass and metal are the chief materials mentioned, and it is on glass and metal that the designs of the majority of lighting fittings have been based.

It is worth while considering the suitability or otherwise of glass and

metal for lighting fittings. Both are heavy, and, since glass in thin sections is very fragile, it is normally used in fairly thick sections, when there is a possibility of its receiving severe mechanical shocks. It follows that the supporting metal framework must, of necessity, also be heavy. This weight question is of great importance, since very stout and expensive canopies and special means of support are required if safety is to be ensured.

One major defect in glass as a constructional material for lighting fittings is its tendency to shatter under relatively mild mechanical and thermal shocks. Lack of thermal shock resistance is, of course, more marked in the case of thick sections than in thin sections, while, in general, the reverse is true when mechanical shocks are considered. Special glasses, such as "Pyrex" brand glass, have low thermal expansions, and will withstand thermal shock very well indeed, but they are expensive and offer difficulties in processing. This tendency to shatter may constitute a real danger to users of lighting fittings containing glass, and special precautions, in the form of close-mesh wire cages surrounding the glass portion in street lighting units, for instance, are often specified

Glass is available as clear, opal, and in many beautiful colours and finishes, and it can be obtained as sheet, blown, or pressed forms. If sheet is to be mounted in metal frames, special methods of mounting have to be provided, and provision made to allow for differential expansion between the glass and the metal. Blown glass imposes some restrictions on design in that shapes with circular cross-sections about one axis are cheaper and usually show the better finish and, while it is possible to prepare a glass unit with any outside contour within reason, it is impossible to control the inside contour to give prismatic effects, for instance. Refracting bowls and plates can be prepared by moulding. Even with a source of light of appreciable dimensions, a high order of accuracy of the refracting prisms is required, and smooth, undistorted, prism faces are necessary to allow ease of cleaning. Molten glass has a high surface tension and a poor heat conductivity, so that, even under the relatively high pressures used in moulding, it is extremely difficult to obtain a faithful reproduction of the mould and avoid distortion of the prisms after the mould has been opened. Moulded glass articles are always heavy and if suspended as a bowl, require very stout canopies while, if used as panels, equally stout metal frames and mountings must be provided.

Glass and metal have a number of important advantages when used in lighting fittings in that they are rigid, are not affected appreciably by exposure and age, offer a high resistance to surface abrasion, and do not soften at the highest temperatures which are encountered. Metal has the added advantage of being able to be shaped in the cold if in reasonably small thicknesses, and can be stamped, spun, and machined easily.

New Materials now Available

Plastics can now be added to the list of materials now available for the construction of lighting fittings. Plastics will allow the illumination engineer more scope in his designs and may even allow revolutionary changes in design. Careful thought will be required, however, before a plastic is selected for a particular job. There has been a tendency to regard plastics as substitute materials, and, their use in war-time may have strengthened this view in the minds of people who are ignorant of, or have not given careful thought to, the special properties which they offer. A range of plastics, which cover a whole spectrum of properties, are now offered to the illumination engineer, and he should consider these properties carefully and prepare his designs with them in mind.

Let us consider the various types of plastics which are available to him in quantity at the present time, or likely to be so in the near future. The usual division of the range of plastics is into thermoplastic and thermosetting, and we shall discuss them under those headings.

(a) THERMOPLASTICS.

As the name implies, these materials soften and can be fashioned into any desired shape by heating to

some temperature characteristic of the particular plastic selected. Thermoplastic materials likely to be readily available in this country are polymethyl methacrylate, polystyrene, cellulose acetate, and ethyl cellulose. Of these, the ones probably best known are polymethyl methacrylate in sheet form under the trade name of "Perspex," and cellulose acetate.

Thermoplastic materials offer many outstanding advantages for the construction of lighting fittings. Thus, they are light in weight, have a remarkable transparency to light, can be shaped and machined easily, and have excellent mechanical properties, all of which are invaluable properties to the designer of lighting fittings. Let us consider these properties in more detail.

The four plastics mentioned have specific gravities ranging from 1.06 for polystyrene to 1.32 for cellulose acetate. These materials, having approximately half the weight of an equivalent piece of glass, will allow lighter fittings to be made and weaker suspensions to be used. Further, it will be found, in general, that appreciably thinner cross-sections can be used in plastics than in glass, so that a considerable saving in weight is possible.

The materials are available in crystal clear, opal, opaque, and in colours. They can be supplied in cast sheet or moulding powder forms. The cast sheets show, in general, a slightly higher light transmission than if moulded from powder. "Perspex" gives the remarkably high light transmission value of 93 per cent., and, to the eye, there is no greater reduction in intensity when an object is viewed through a 12-inch thickness than through a 1-inch thickness. The transmission factor for polystyrene is also high at 90 per cent., but that of cellulose acetate is slightly lower. This material is naturally slightly yellow, and it is usual to "decolourise" it by adding a blue dye. The transmission factor of ethyl cellulose is also less than that of "Perspex." If the materials are required to diffuse the light passing through them, they can be given a surface treatment such as sand-blasting, etching, or embossing, or some light scattering filler can be incorporated in them. By the use of dyes, the clear or diffusing sheets can be given practically an unlimited range of colours. The opal varieties can be produced in a range of densities with a light absorption factor of the order of 10 per cent. The clear sheets are stable to light, and tests in which they have been exposed to the radiation from a carbon arc for very long periods have shown no change in the transmission factor of "Perspex," and only a very slight yellowing of the other materials.

The sheet materials, when heated to the correct temperature, become pliable and can be shaped by stretching over formers, blown to shape, blown into a mould, or pressed in a mould. Simple bends can be made by heating the sheet locally and manipulating it by hand. In all these methods of forming the sheet into the desired shape, care must be taken to avoid distortion and preserve the optical qualities of the sheet. Thus, the moulds, which can be of wood unless a large number of shapings of one type will justify the expense of a highly-polished metal mould, must have a perfectly smooth surface otherwise the plastic sheet, which reproduces exactly the imperfections in the mould surface, will be uneven and scatter the light which is passed through it. The stretching of the pliable sheet, and the temperature over the whole sheet must be even if sharp variations in thickness are to be avoided. It will be appreciated that this ease of shaping, together with easy cutting, machining, and drilling, using normal wood-working tools, make thermoplastics of considerable value to the designer of lighting fittings and allow him great scope in producing special fittings to fit in with a particular architectural scheme at a moderate cost. Further, they allow him to keep one stock of flat sheets which can be shaped and cut to any form and size he may require.

It has already been mentioned that the thermoplastic sheets allow accurate reproduction of the surface of the mould. This is of very great importance in the moulding of refractor bowls and plates. The prisms are accurate in shape and take the surface

finish of the polished mould so that accuracy in performance is obtained. Further, there is no chemical attack on the metal mould, and the moulding temperatures are sufficiently low to make mould maintenance simple and inexpensive.

Units of the required form can be prepared from moulding powders by heating the powder in a mould to the correct temperature and closing the mould under pressure, when the material will flow and take up the shape of the mould. After cooling in the mould, the moulded article can be removed. Injection moulding is often used when rapid production of a large number of small mouldings is required. Here, the powder is heated in a separate chamber and then forced under pressure through a nozzle into a mould. Articles made from moulding powder are, in general, less satisfactory optically than those made from sheet, and the powder would normally only be preferred for mouldings of intricate design.

The four plastics selected have good mechanical properties. Their tensile and compression strengths are such that they can be used as structural materials in lighting fittings. The designer has, therefore,, probably for the first time, a range of materials from which he can construct lighting fittings and which can be used both as structural materials and for controlling the light distribution. If it is desired to mount the sheets or shapings in a framework of another material, such as metal, the panels can be flexed and bent slightly to fit into grooves and the use of screws and hinges can thus be avoided. The materials will withstand severe thermal and mechanical shocks, the latter, together with lightness in weight, allowing easy handling during lamp changing and cleaning.

Special methods of cementing together pieces of a thermoplastic material have been developed. The methods are simple and are equivalent to fusing together the two pieces so that the joint has practically the same mechanical strength as that of the material itself. No complicated equipment is required to make these joints.

Thermoplastics can be silvered either in their flat sheet or shaped and moulded forms. Chemical silvering is not too successful, and the method which has given excellent results is by vapourising the metal under reduced pressure and allowing it to condense on to the surface of the material. This latter method is clean and straightforward, and is preferred by some of the American firms for silvering glass.

It should not be imagined that thermoplastics can be applied without thought and consideration. It has already been mentioned that they soften and deform at high temperatures, so that the lighting fittings should be designed to avoid over-heating. The safe working temperature will depend on the stress which is applied to the material. In general, a safe working temperature is round about 75 deg. C. for the four plastics under consideration, although types of "Perspex" and polystyrene are available which allow the temperature to be increased up to nearly 100 deg. C.

Compared with glass, all thermoplastics are soft and are easily scratched. The scratches are, however, of a different type from those on glass. Microphotographs show that the edges of a scratch on glass are rough and broken and give considerable light scattering. A scratch on the surface of any of the four thermoplastics is simply an indentation in the material, and any deflection of the light is regular and confined to the actual area of the scratch. In this connection, it might be mentioned that spectacle lenses made from "Perspex" have been in constant use for very long periods before the scratches on the surfaces caused by cleaning have impaired vision through them. Finally, all four materials have a linear coefficient of thermal expansion of the order of 10^{-4}, and due allowance must be made for this in designing a lighting fitting.

(b) THERMOSETTING.

Thermosetting plastics differ from thermoplastics in that, after being moulded, they cannot be softened and shaped by the application of heat. They are supplied in the form of moulding powders, and during moulding the materials first soften and take up the shape of the mould, and then, under the influence of the heat and

pressure, a chemical action takes place and they set rigid. To use thermosetting materials for lighting fittings, therefore, it is essential to have a metal mould which will give the actual shape of the globe or panel required.

From the range of thermosetting plastics available we shall select only urea-formaldehyde and melamine-formaldehyde as being suitable for light control. The actual resins are transparent and brittle, and their good mechanical properties, with which we are familiar, are imparted to them by the incorporation of fillers. Depending on the fillers which are used, the materials can be produced as a range from translucent white to opaque white and in a practically unlimited range of colours. Urea-formaldehyde in pastel shades is particularly attractive.

Urea-formaldehyde and melamine-formaldehyde are light in weight with specific gravities below 1.5, and thus offer a substantial saving in weight when compared with glass. They possess a certain degree of flexibility, and panels can be bent slightly to allow easy assembly in metal frames. The mechanical strength of both materials is good, and the impact strength is such that they can withstand severe mechanical shocks. In addition they can withstand severe thermal shocks. As with thermoplastics, these materials can be used, therefore, for structural as well as light controlling purposes in lighting fittings.

The fact that thermosetting plastics do not soften at high temperatures, as thermoplastics do, does not mean that the materials can be used continuously at high temperatures. If the temperature is too high the materials discolour and char, and, while urea-formaldehyde may withstand appreciably higher temperatures for short periods, it is inadvisable to use it continuously at temperatures very much in excess of 75 deg. C. It is claimed for melamine-formaldehyde that it can be held at a temperature some 20 deg. C. higher than this without suffering any harmful effects.

The "opal" varieties of both urea-formaldehyde and melamine-formaldehyde give excellent diffusion with overall efficiencies of the order of 90 per cent., and can be made in a range of densities from light through dense to opaque. The translucent varieties can be used, and particularly in colours, to give very attractive decorative effects. Many of you are familiar with urea-formaldehyde shades which have been on the market for a number of years. These can be produced with a highly polished surface finish or matt finish, depending on the finish of the mould which is used.

Although thermosetting plastics cannot be shaped after moulding, they have the advantage over glass in that they can be cut, machined, and drilled relatively easily. Compared with the thermoplastics they are hard and have a high resistance to surface abrasion, so that there is very little risk of the surfaces becoming scratched in use.

Urea-formaldehyde, even in its coloured forms, is entirely unaffected by exposure to bright sunlight for very long periods. There is some slight change in colour in the case of melamine-formaldehyde. The latter material will not burn, while urea-formaldehyde burns so slowly as to be classed as non-flammable. Both materials have a good resistance to chemicals, being attacked to any appreciable extent only by strong acids and alkalies.

Where very large translucent, opal, or opaque panels are required, interest will be shown in laminated sheets prepared from urea-formaldehyde and melamine-formaldehyde resins. These sheets are prepared by impregnating fabric or paper with the resins in liquid form, building up these impregnated layers one on top of the other until a sheet of requisite thickness is obtained, and hardening or "curing" this sheet under heat and pressure to give a rigid, composite sheet of very high mechanical strength. Very attractive sheets can be formed which are sufficiently rigid to be used in large areas with only edge support. By the addition of dyes and pigments, these sheets can be produced in colours.

Another type of plastic which can be classed under the heading "thermosetting" in that, once formed, they cannot be softened and shaped by heating, is the so-called "cross-linked"

type of resin. These resins, which are still in their early stages of development, have found a number of applications in war-time. The one which is probably best known is Columbia Resin 39, which has been developed and used, to a limited extent, in America.

Most of these resins can be cast in the form of crystal-clear sheets, which have a reasonable degree of flexibility, and offer a high resistance to abrasion. Regarding this question of abrasion resistance, the materials are not hard as we understand glass to be hard, but rather show a remarkable recovery from indentation. Although the finished sheets cannot be shaped however strongly they are heated, it is possible to arrest the chemical reaction at one stage of their manufacture and soften them at this intermediate stage by heating to allow a limited amount of shaping. The materials do offer advantages over glass in that cutting, machining, and drilling are relatively simple, so that a stock of sheets will allow flat panels of any size and shape to be made without the use of special tools and equipment.

There have been references recently in the American technical press to the use of cross-linked resins for preparing laminated sheets. If glass fabric is used, for instance, for the layers, exceptionally high mechanical strength is claimed. Where very high mechanical strength combined with high abrasion resistance, a certain degree of flexibility and attractive appearance are required, these laminated materials are likely to prove of considerable importance to the illumination engineer.

Specific Applications for Plastics

It may be of interest to consider suggestions for the use of plastics in a few specific lighting applications. The illumination engineer himself will know best how to take full advantage of the materials, and these suggestions should be regarded simply as examples of lighting applications which the plastics technician, from his knowledge of the materials, knows are possible.

(a) Light Sources

It is clearly impossible to consider the present plastics as constructional materials for incandescent and discharge lamps owing to the high temperatures which are obtained, but with the fluorescent lamp where temperatures are quite low it might be possible to use some of them as envelope materials. Some of the thermoplastics will be available in the form of tubes, and while experiments have shown that "Perspex," for instance, is unsuitable where extremely high vacua are required, it might stand up to the running conditions obtained in a fluorescent lamp. Experiments in this connection may be worth while carrying out, although some changes in design might be necessary. Plastic tubes would offer a saving in weight and high resistance to mechanical shock.

(b) Street Lighting

It has already been mentioned that very accurate reproduction of the mould is possible with plastics. The transparent thermoplastics would allow accurate refractors for street lighting units to be made and give an increased accuracy in light distribution. Moulded glass refractors are, of necessity, very heavy, and a great saving in weight due to the low specific gravity of the plastic, and the fact that it can be used in thin cross-sections, could be effected. The removal of any risk of shattering from thermal and mechanical shocks would obviate any necessity for protective cages. The total saving in weight would, therefore, be very considerable and, in consequence, much lighter supports could be used. For the reflecting and diffusing portions of the unit, a range of "opal" and white opaque plastics are available. The use of plastic street lighting units would reduce the risk of breakage during storage, cleaning, and lamp-changing, and much simpler methods of construction of the unit could be used.

Advantage might be taken of the reduction in weight to build larger and more attractive street lighting units. With thermoplastics it will be

no longer necessary to keep as much as possible to the flat sheet form as it is with glass if the expense and storage costs are to be kept low.

It is not suggested that plastics could be used indiscriminately for street-lighting units. Changes in design might be required in order to prevent over-heating of the materials, but the maximum temperatures which plastics will withstand are such as to impose no great difficulties in designing on the illumination engineer.

(c) Industrial Lighting

Following the usual methods of lighting industrial premises, there seems no real reason why the common vitreous enamelled type of reflector should not be made in plastics. The tendency to provide a small amount of illumination in the upper part of the workshop could be followed by using a dense but not opaque plastic for the reflector. Surfaces would be smooth and allow easy cleaning, there would be no flaking of the surfaces, and there would be a considerable saving in weight. The disadvantages compared with the normal vitreous enamelled iron unit would be a reduction in mechanical strength and the necessity to avoid over-heating.

It is, however, not with past but with future lighting systems that we are primarily concerned, and there seems little doubt that fluorescent lighting will find its place in industrial lighting. Developments towards providing higher wattage fluorescent lamps, which will allow economic lighting of industrial premises, have been made. Unfortunately, the increased length of these high-wattage sources makes efficient light distribution much more difficult. We have been accustomed to seeing fluorescent lamps in trough reflectors, but something better than this is required if even illumination is to be obtained without using an uneconomic number of units. The answer to the problem might be a reflector together with a large refractor below the source. Both reflector and refractor could be in plastics without there being any risk of over-heating. A combined unit of this description would be light in weight, easily constructed, and cleaned without risk of breakage.

(d) Lay-lighting

With our increased appreciation of the value of good lighting may come a tendency to make more use of lay-lighting. Lay-lighting can be very attractive and made to fit in with the decorative scheme of a room and bring out special decorative features.

For lay-lighting it has been necessary to use large diffusing glass panels involving special means of support, or a number of smaller panels each requiring edge support. Plastics can obviously be used in place of glass panels with advantage since they are light in weight and, by virtue of being slightly flexible, can be placed in position without difficulty. Further, refractor plates of thin cross-section and lightness in weight, with their refracting prisms arranged in attractive patterns, could be substituted for the diffusing panels and give a more accurate distribution of illumination, particularly in the case of fluorescent lamps, over the whole area of the room. A complete range of tints would also be readily available

(e) Shop, Hotel, and Cinema Lighting

In shop, hotel, and cinema lighting attempts have been made to treat lighting as a part of the decorative scheme. The expert designer will appreciate much more than the author can do the possibilities offered by materials which can be used as large clear, diffusing and refracting panels in an unlimited range of colours, and which can be shaped and bent at will to fit in with the decorative scheme.

He will also appreciate the possibilities offered for the use of patterns in deep relief and the attractive refraction effects which can be obtained from sharp changes in thickness. He will probably wish to use tinted laminated plastic sheets, with their permanent colours and abrasion resisting surfaces, to obtain attractive decorative lighting effects. As a further attraction to the designer, he will appreciate the fact that the weight involved will be only a fraction of that

of glass, the chief material on which he has always had to rely.

The materials can be used as large silvered panels, or silvered moulded reflectors, and as such can be employed for interior and shop-window lighting.

(f) LIGHTING IN THE HOME.

Much of what has already been said concerning special lighting systems will apply to the use of plastics in providing efficient and decorative lighting in the home. It is worth while, however, emphasising the contribution which plastics can make in connection with fluorescent lighting in the home. It has already been mentioned that large fluorescent lamps have been developed. 6-watt lamps, with a length of only 9 inches, have also been made and are likely to find use in the home. It is common to have only one or two lighting units in a room, and it is obvious that, under these circumstances, care should be taken to obtain the correct light distribution. A refractor panel or panels, used in conjunction with a reflector, probably might give the required distribution and allow attractive fittings to be constructed. Tinted plastics will also help in adding to the appearance of a unit which, on account of the shape of the light source, may offer some difficulties in design.

More use might be made of plastics in the construction of standard and reading lamps. Some of the clear and tinted thermoplastic materials are available in the form of rods and, since they can be readily machined and turned in a lathe, the construction of very attractive reading lamps should not be difficult.

Conclusion

An attempt has been made to show how the advent of plastics into the lighting field can enlarge the scope of the designer of lighting fittings. It is, and will be more so in future, the responsibility of the designer to provide both efficient illumination and units in character with the room in which they will be installed. For larger installations, lighting should be a part of the architectural form and a feature of the construction itself. The ease of manipulation of thermoplastic sheets should provide the extra degree of freedom which was not obtained with the older materials.

Finally, it should be emphasised once again that plastics cannot be treated in the same way as glass and metal. Each plastic has its own characteristic properties, and careful consideration should be given to these when a selection is made for a particular lighting application. It has been pointed out that plastics cannot withstand high temperatures for long periods, and it is only through appreciating this fact and designing with it in mind that the illumination engineer will be able to use them successfully. Fortunately, his designs will not be limited in any way by temperature considerations in the case of fluorescent lamps, and it is with fluorescent lighting that he will be concerned more and more in the future. In any case, the research effort being expended on plastics is very great, and it is probably not too optimistic to expect that this temperature limitation will be removed in the future.

Fellowship.

The following applications for Fellowship have been accepted:—

Jones, Professor T. David.
Tabraham, D. L.
Thompson, F. M.
Wilman, Major D.
Wilson, N. G.

Proposed Increase in Subscriptions

Extraordinary General Meeting held on November 14th, 1944

In opening the proceedings the President (Mr. E. Stroud) called upon the Hon. Secretary to read the notice convening the meeting, which contained the terms of the Resolution now to be presented. This was as follows:—

That the subscriptions of Members payable on January 1, 1945, and thereafter be modified, and that By-Laws 18 and 21 be amended to read as follows:

18. The annual subscription to the Society shall be as follows:

	£ s. d.
Fellows	3 10 0
Corporate Members (except Fellows and as provided by By-Law 9 (iv.)	2 10 0
Country Members and Associates	1 10 0
Students (under 21 years of age)	0 10 0
Students (over 21 years of age)	1 0 0
Sustaining Members (minimum)	5 5 0

Honorary Members shall be exempt from all subscriptions.

21. The annual subscriptions of Corporate Members who have attained the age of thirty-five years may be compounded by payment of the following sums:—

	35-44 years of age.	Over 45 years of age.
Fellows	£45	£35
Other Corporate Members	£30	£25

A Member who has already compounded for his subscription as a Corporate Member may, on becoming a Fellow, either pay an additional annual subscription of £1 or compound for the additional subscription by a supplementary payment of £10.

For the sake of brevity he suggested that the terms need not be repeated and that speakers should refer merely to "The Resolution."

Proceeding, the President recalled the printed circular issued to all members explaining the reasons that had led the Council to make these proposals which had since been fully discussed at a meeting of the Areas Joint Committee. At the suggestions of that Committee a personal appeal by him had also since been circulated. In response he had received many cordial letters, all expressing agreement with the proposals and some couched in very generous terms. He understood that at some Centres and Groups, for example Birmingham, Newcastle, and Huddersfield, resolutions in favour of their adoption had been passed, though at others some difference in opinion seemed to exist.

Three members of the Society were intending to exercise their constitutional rights of demanding a poll. He suggested, however, that in the first place the meeting should discuss the proposals themselves, following which the question of further procedure could be raised.

The Resolution was then presented by the President and seconded by Mr. R. O. Ackerley.

Mr. HOWARD LONG (Birmingham Centre) stated that at the Birmingham Centre a resolution expressing unanimous approval of the proposals had been passed. It was realised that this was the only means by which the Society could progress. He believed that members generally were in favour of the proposals and the demand for a poll was due merely to the desire to permit everyone to express his personal views.

Mr. ALAN OWEN (Manchester Centre) said that he and the Chairman of the Manchester Centre had been asked to vote against the proposals. It was agreed that additional revenue was necessary, but it was felt that the present was an inopportune moment to take the decision to increase subscriptions, which should only be done when all other efforts to raise revenue had failed.

Mr. Owen then referred to rapid progress in the membership of the Birmingham Centre and to recent additions in Liverpool. Since the outbreak

of war the membership of the Society had nearly doubled. Increased subscriptions might lead to the loss of some members and would prevent others from joining. He believed that over a period of five years 5,000 Corporate Members and 150 Sustaining Members and an annual revenue of £13,000 could be secured. The Society was in a solvent condition Let the paid secretary be appointed and new premises obtained. By that time it would be possible to survey progress and to judge the position better.

Mr. N. C. HODSON (Chairman of the Manchester Centre) also emphasised the growth in membership, which might solve the problem quite soon, whereas increases in rates might deter progress.

Mr. R. O. ACKERLEY, whilst appreciating the enthusiasm shown by members in Manchester, pointed out that the Society required the money *now*. Development could not proceed properly until the Society had the larger staff and the new offices it needed.

Mr. G. H. GILES supported the proposals and agreed that an increase in revenue of at least £3,000 per annum was needed.

Mr. J. S. Dow (Hon. Secretary), winding up the discussion, referred in appreciative terms to the work of Mr. Owen in Manchester. Nevertheless, he endorsed the point made by Mr. Ackerley. Additions to membership were being secured largely by the formation of new Centres and Groups, which brought increased revenue but also greater expenditure. The surplus of income over expenditure shown in recent years was largely due to exceptional conditions imposed by the war. The Society could not spend in many desirable directions—for example, in improving the Transactions, at present crippled by restrictions in regard to paper. He, like the President, had received many letters endorsing the proposals.

In conclusion, Mr. Dow said that during his long period of service he had often commented on the generous support which so many members gave to the Society. He felt sure they would willingly make the small additional sacrifice now requested.

The resolution was then put to the meeting and, on a show of hands, was declared carried by 36 votes in favour and 5 against.

The President then announced that three members, Mr. T. Wilkie, Mr. E. G. Phillips, and Mr. A. J. Pashler, on behalf of the Midland Area, had made a written request for a poll, in accordance with Clause 24 in the Articles of Association. He asked all members present to be sure to return their proxies and to do their best to secure that a representative vote was obtained. The voting would take place at a second Extraordinary Meeting, which would be held at 4.30 p.m. on December 12. All proxies must be returned seven days before the meeting.

On the motion of Mr. W. J. Jones, Mr. C. A. Morton and Mr. F. M. Cocksedge were appointed scrutineers.

As arranged at the above meeting a vote was taken on the date specified, when it was announced that the Resolution had been carried by a large majority, the actual figures being 617 for the Resolution and 124 against.

The Chairman pointed out that over 80 per cent of the votes cast were in favour of the Resolution. The amendment in the By-Laws had therefore been approved by much more than the "two-thirds of the members qualified to vote and voting," specified in the Articles, and would come into effect in due course.

A cordial vote of thanks to the Scrutineers terminated the proceedings.

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

With a view to avoiding possible confusion with other publications, reference to these Transactions should be in the form :—" Trans. Illum. Eng. Soc. (London)."

SESSION 1944—1945

LIST OF I.E.S. REGIONAL COMMITTEES

AREAS:

MIDLAND AREA.

Chairman: A. J. Pashler. *Committee:* C. S. Caunt, E. Howard, J. Martin, J. H. Nelson, E. G. Phillips, M. R. H. Sadler, F. J. Stanyon, W. J. P. Watson, C. S. Wheeler. *Hon. Secretary:* C. J. Allderidge. 125, Moor Street, Birmingham.

NORTH MIDLAND AREA.

Chairman: E. C. Walton. *Committee:* T. C. Holdsworth, A. J. Holland, J. H. Mollan, R. Pye. E. G. R. Taylor. W. G. Thompson. *Secretary:* J. A. Whittaker, Magnet House, Fitzalan Square, Sheffield, 1.

CENTRES:

BATH AND BRISTOL CENTRE (WESTERN AREA).

Chairman: E. J. Ireland. *Vice-Chairman:* R. E. Tucker. *Hon. Treasurer:* S. M. Richman. *Committee:* R. G. Capell, R. S. Hazell, E. A. Jacobs, W. A. Laughton, L. C. Rettig, W. S. Shaw, H. J. Weston. *Hon. Secretary:* D. J. Sawkins, 86, Redcliffe Street, Bristol. *Hon. Asst. Secretary:* A. E. Hayward.

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LEICESTER CENTRE (MIDLAND AREA).

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LIST OF I.E.S. REGIONAL COMMITTEES—SESSION 1944-45

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Chairman: N. C. Hodson. *Vice-Chairman:* H. C. White. *Past Chairmen:* W. H. Smith, J. A. Somerset. *Hon. Treasurer:* W. M. Fisher. *Committee:* H. Atherton, W. Browning, H. Etchells, J. H. Lumsden, K. R. Mackley, J. H. Morrison, W. C. Sherry, M. C. Toner, J. Walsh. *Hon. Secretary:* Alan H. Owen, 11, Albert Square, Manchester.

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GROUPS:

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Sessional Meeting in London

A Sessional Meeting took place at the E.L.M.A. Lighting Service Bureau (2, Savoy Hill, London, W.C.) at 5.30 p.m., on November 14, when the President (Mr. E. Stroud) took the Chair.

After the Minutes of the last meeting, which had been circulated, had been taken as read, and the Honorary Secretary had announced particulars of forthcoming meetings, the President called upon Mr. J. N. Aldington to deliver his paper entitled "Bright Light Sources."

This paper, which was illustrated by numerous demonstrations, dealt with tungsten filament projector lamps. The lecturer described and illustrated various types, including (a) straight single coil lamps, (b) flat grid projector lamps, (c) multi-planar projector lamps, (d) coiled coil filament lamps, (e) uniform sources, and (f) multi-filament lamps. The comparative advantages of these various types were discussed. Special reference was also made to the "solid source" effect and to types of lamps using internal reflectors.

The discussion was opened by Mr. D. McGill, of the Admiralty Signal Service. Others who took part included Mr. J. G. Holmes, Dr. S. English, Mr. Cecil Hughes, Mr. J. M. Waldram, Mr. G. T. Winch, Mr. W. Stevenson, and Mr. F. C. Smith.

After the author had replied to the various questions put, a vote of thanks to Mr. Aldington for his interesting paper was carried with acclamation. The meeting terminated with a further vote of thanks to the E.L.M.A. Lighting Service Bureau for their hospitality.

Additions to List of Members.

The following applicants have been duly elected by the Council to membership in the Society, and their names have been added to the list of members:—

SUSTAINING MEMBERS:—

E. K. Cole, Ltd. ..... *Representative*: E. S. Evans.
Southend-on-Sea, ESSEX.

Dodd and Oulton, Ltd. ..... *Representative*: S. N. Smedley.
8/12, Stanley Street, LIVERPOOL, 1.

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Needham, E. .....2, Clwyd Avenue, Edgeley Park, STOCKPORT.
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Reid, Geo. ....."Lufra House," Granton Road, EDINBURGH.
Stokes, J. S. ....."Mon Abri," Somerby Hill, Grantham, LINCS.

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